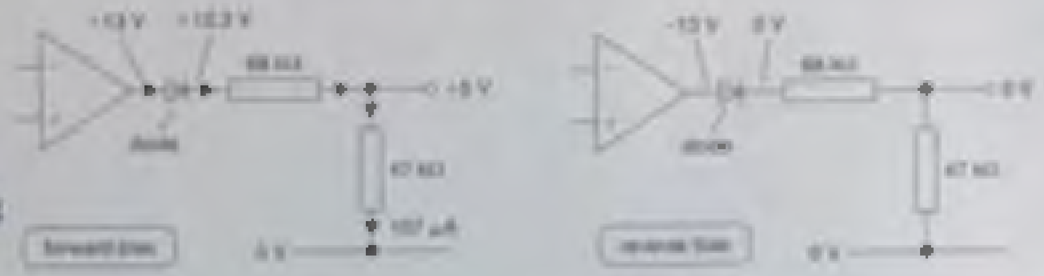
Diodes

Logic gates cannot handle negative voltages at their inputs, so the output of an op-amp cannot be fed directly into one. A **diode** is necessary to only let positive voltages through, as shown in Fig. 2.13.

Fig 2.13 Charge only flows through the diode when it has forward bias.

Remember : The Diode takes 0.7 V .



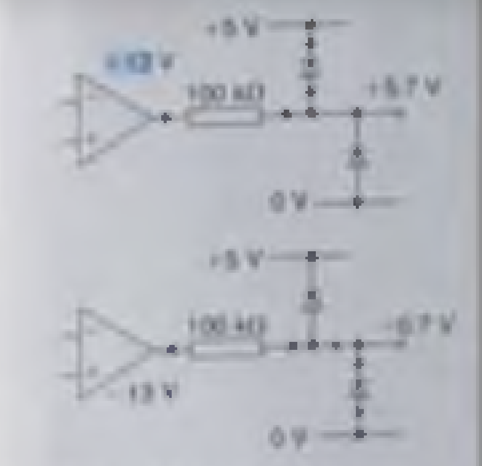
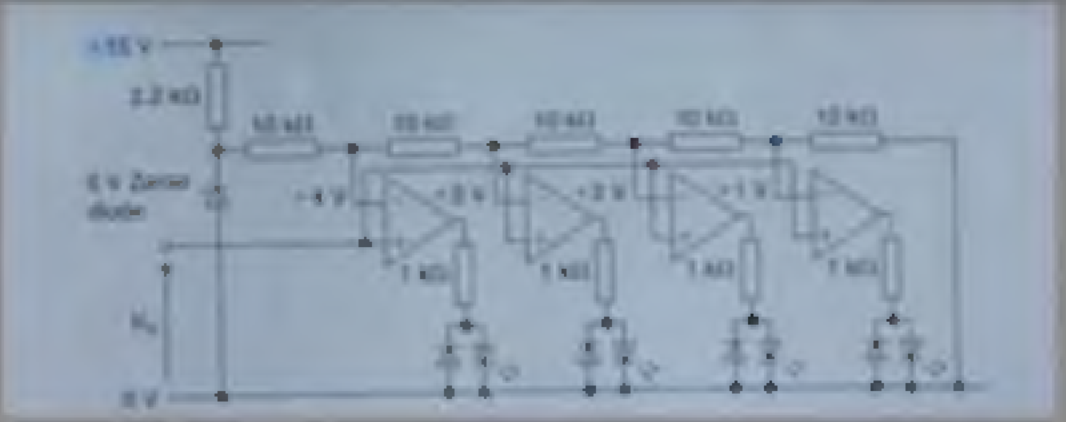
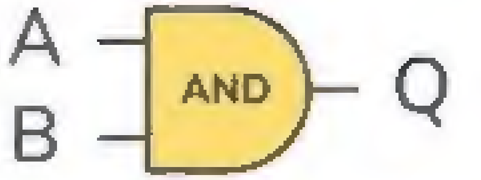


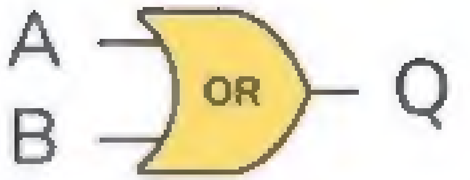
Fig 2.15 One diode is always in forward bias, clamping the output voltage close to the supply voltage



The **Zener diode** generates a fixed +5 V from the +15 V supply (for details see the next page). Five 10 kΩ resistors make a **resistor ladder** which generates voltages of +4 V, +3 V, +2 V and +1 V. Each of the four op-amps compares the incoming signal V_{in} with one of these four fixed voltages. If V_{in} is greater than the voltage at an non-inverting input, the output of an op-amp saturates at +13 V, putting the LED in forward bias and making it glow. The silicon diode in parallel with each LED clamps the reverse bias voltage to −0.7 V: well below the breakdown voltage of −5 V for a typical LED.



A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

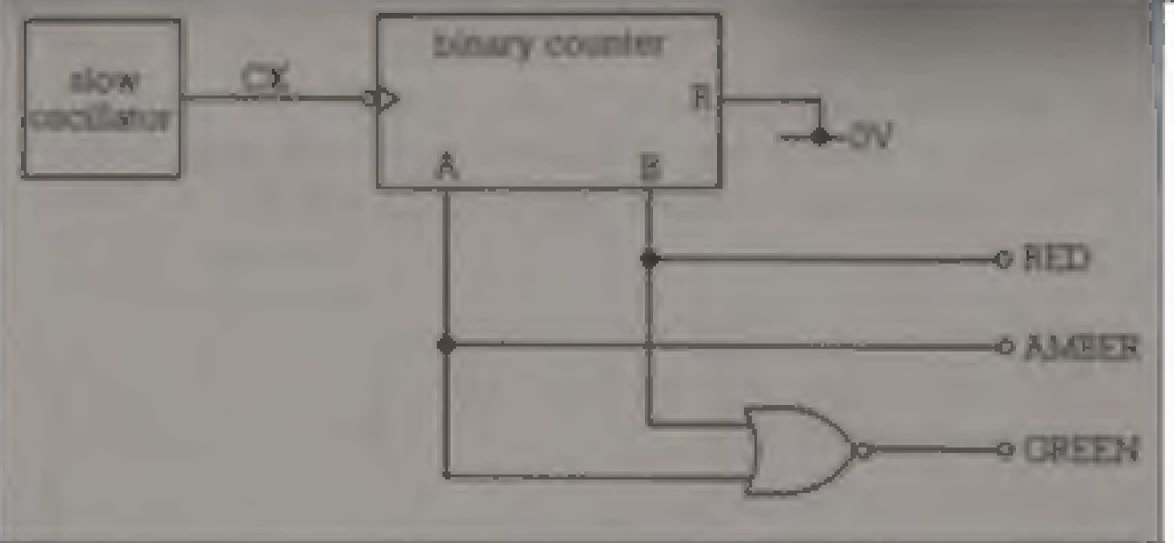


A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

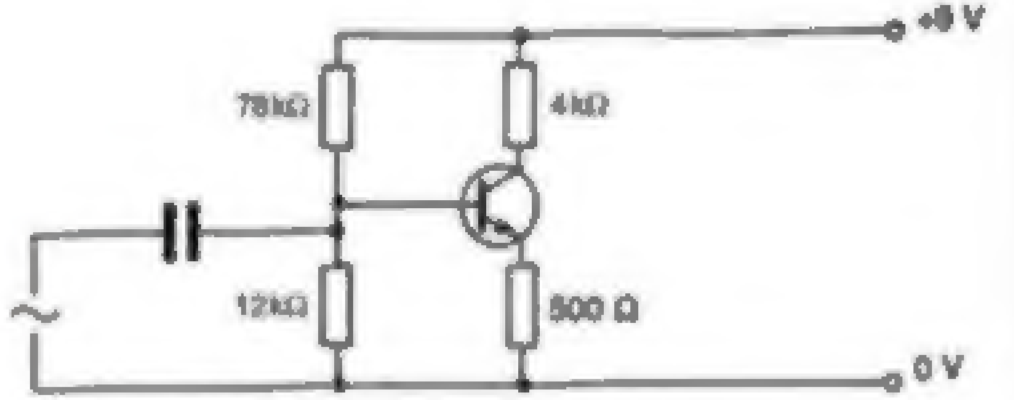
Double Angle Formulas	Half Angle Formulas
$\sin 2\theta = 2\sin\theta\cos\theta$	$\boxed{\sin^2\theta = \dfrac{1-\cos 2\theta}{2}}$
$\cos 2\theta = \cos^2\theta - \sin^2\theta$	$\sin\dfrac{\theta}{2} = \pm\sqrt{\dfrac{1-\cos\theta}{2}}$
$= \boxed{2\cos^2\theta - 1}$	$\boxed{\cos^2\theta = \dfrac{1+\cos 2\theta}{2}}$
$= \boxed{1-2\sin^2\theta}$	$\sin\dfrac{\theta}{2} = \pm\sqrt{\dfrac{1+\cos\theta}{2}}$
$\tan 2\theta = \dfrac{2\tan\theta}{1-\tan^2\theta}$	$\tan\dfrac{\theta}{2} = \pm\sqrt{\dfrac{1-\cos\theta}{1+\cos\theta}}$



B	A	RED	AMBER	GREEN
0	0	0	0	1
0	1	0	1	0
1	0	1	0	0
1	1	1	1	0

For a given mass of gas, the volume, V cm^3, and pressure, p cm of mercury, are related by $p = kV^n$ where k and n are constants.

(a) Prove that $\dfrac{dp}{dV} = \dfrac{np}{V}$



2 The circuit of Fig. 2.1 shows a fully stabilised voltage amplifier. The transistor has a d.c. current gain (h_{FE}) of 100.

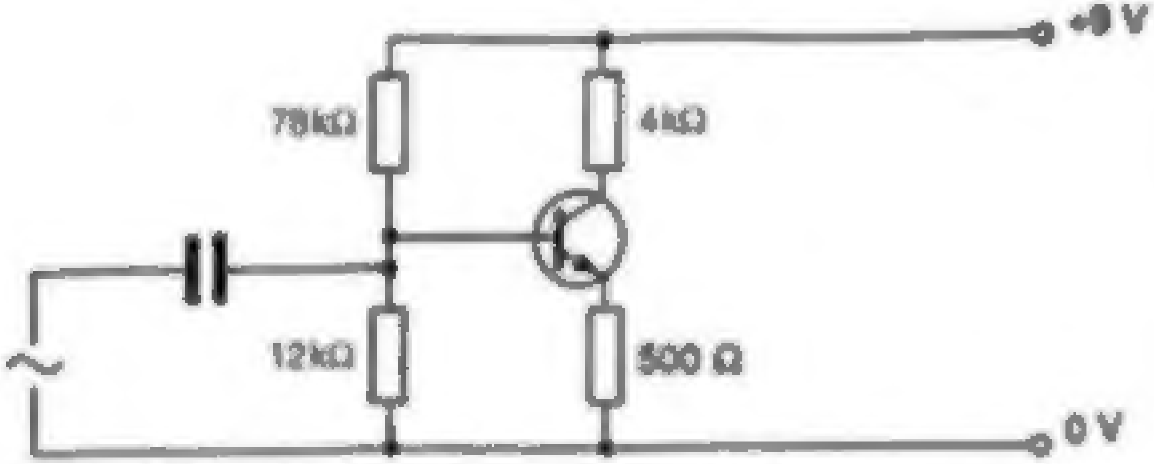


Fig. 2.1

(a) Calculate the voltage at the base.

(b) Calculate the emitter current.

(c) Calculate the voltage of the collector.

9 - ((0.3 / 0.5) * 4) =

6.6

(d) A sinusoidal input signal of frequency 1 kHz and peak value 200 mV is now applied to the base via a capacitor. Draw two sketch graphs of the voltages on the base and collector as functions of time for two cycles of the input. Label the graphs. [3]

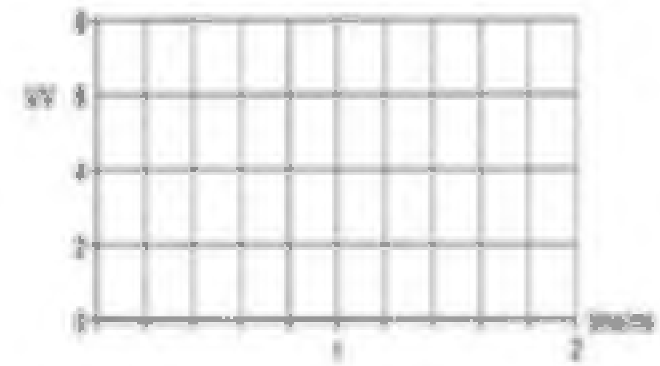


Fig. 2.2

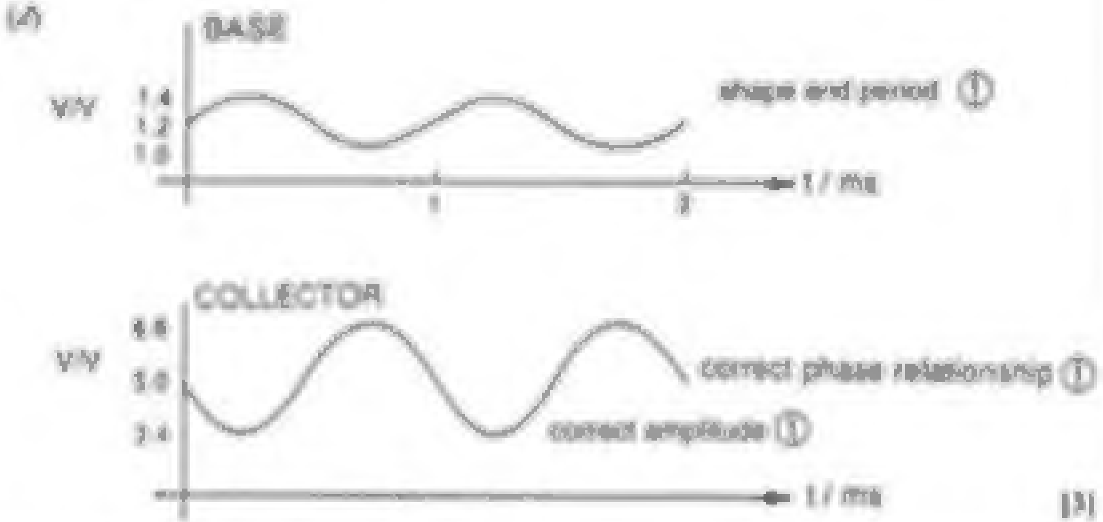
[Total: 7]

(a) $V_{base} = \frac{12}{12 + 78} \times 9 = 1.2\ V$ [1]

(b) $I_e = \frac{1.2 - 0.7}{0.5} = 1\ mA$ [1]

(c) $V_c = 9 - I_c R_c = 9 - 1 \times 4 = 5\ V$ [2]
[1] [1]

(d)



[3]

Note:
The current gain formula is valid **only** in the linear region. However, it can be used right up to the point where the transistor enters saturation. Examination questions are worded in the following or similar manner:

Determine the value of V_{IN} that will cause the transistor **just** to saturate.
or The transistor is **just** saturated when the input voltage V_{IN} = 2.5, etc.

This phraseology allows the equation to be used.

Simplify the following expressions.

2. $\dfrac{1-\sec^2 A}{1-\operatorname{cosec}^2 A}$

3. $\dfrac{\sin\theta}{\sqrt{(1-\cos^2\theta)}}$

4. $\dfrac{\sin\theta}{\cos\theta}+\dfrac{\cos\theta}{\sin\theta}$

5. $\dfrac{\sqrt{(1+\tan^2\theta)}}{\sqrt{(1-\sin^2\theta)}}$

6. $\dfrac{1}{\cos\theta\sqrt{(1+\cot^2\theta)}}$

7. $\dfrac{\sin\theta}{1+\cot^2\theta}$

2. $\tan^4 A$
3. 1
4. $\sec\theta\operatorname{cosec}\theta$
5. $\sec^2\theta$
6. $\tan\theta$
7. $\sin^3\theta$

$$\sec^2 A = 1+\tan^2 A$$

$$\csc^2 A = 1+\cot^2 A$$

$$\frac{2+2\cos(A)}{(1+\cos(A))\cdot\sin(A)}$$

Factor out 2 from the expression

$$\frac{2(1+\cos(A))}{(1+\cos(A))\cdot\sin(A)}$$

$$\frac{\frac{1}{\sin A}}{\frac{\cos A}{\sin^2 A}}$$

$$\frac{2(1+\cos(A))}{(1+\cos(A))\cdot\sin(A)}$$

Cancel out the common factor $1+\cos(A)$

$$\frac{2}{\sin(A)}$$

$\dfrac{1}{\cos^2 A}$ $\dfrac{1}{\tan A}$

$\dfrac{1}{\cos^2 A}$ $\dfrac{\cos A}{\sin A}$

Simplify the complex fraction:

$$\frac{1}{\sin A}\cdot\frac{\sin^2 A}{\cos A}$$

$$\frac{\sin^2 A}{\sin A\cos A}$$

$$\frac{\sin A}{\cos A}$$